Clinical Impact of the Couch Top and Rails on IMRT and Arc Therapy

Kiley Pulliam, Rebecca Howell PhD, David Followill PhD, Dershan Lou PhD, R. Allen White PhD, Stephen Kry, PhD

The University of Texas M. D. Anderson Cancer Center, Houston, TX

THE UNIVERSITY OF TEXAS MD Anderson Cancer Center

Introduction

There is an assumption in external beam radiation therapy that the treatment couch (comprised of both the couch top and, for some models, movable support rails) is a non-attenuating structure because of its low-density carbon fiber composition As such, it is not generally taken into account during treatment planning, even for posterior fields.

However, numerous studies have demonstrated non-negligible attenuation by the couch top and movable rails between 4-17%[1,2,1] where the rails consistently showed greater attenuation than the couch top. While some clinics may move the rails from the beam's path to avoid this attenuation during IMRT treatments, this is far from universal practice. This issue is further complicated during the delivery of Arc Therapy treatments as it is not feasible to move the rails to avoid them during treatment.

Therefore, this study assessed the clinical impact of the couch top and rails on target dose, coverage loss, and tumor control probability (TCP) for both IMRT and Arc Therapy. This was done using the Eclipse treatment planning system (Varian Medical Systems, Palo Alto CA), which includes models of a variety of Varian Exact treatment couch components.

Methods

Five patients were planned with both a clinical 6-MV, 8-field IMRT and 6-MV, 2-arc RapidArc without the couch or rails, as is done clinically. All plans met MDACC planning criteria for target dose and coverage (98% prostate and 95% of PTV receiving 76 Gy) and normal tissue DVH constraints.

Each of these clinical plans was then copied and had Varian Exact treatment couch structures inserted in the following configurations:

1. Imaging insert with rails out (referred to as 'rails-out' plan)
2. Imaging insert with rails in (referred to as 'rails-in' plan)
3. Imaging insert only (referred to as 'couch top only' plan, representing a scenario where the rails avoided for IMRT but not clinically deliverable for RapidArc)

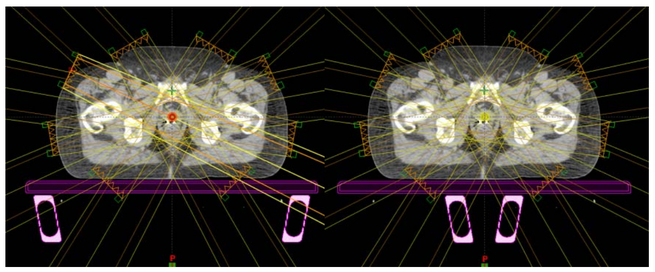

Figure.1. IMRT beam arrangement with couch top and rails included (rails-out plan left and rails-in plan right)

- To validate Eclipse couch model, point dose measurements in an IMRT QA phantom (IBA Dosimetry Bartlett, TN) were taken and compared to the TPS calculated dose with and without the couch included in calculations.

- The DVH's were used to evaluate dose and coverage loss to targets and normal tissues. Qualitative analysis was performed using plan subtractions.

- The tumor control probability (TCP)for each plan was calculated using script based on a clinically implementable TCP model[4]. Using biological input parameters derived from clinical data from Levegrun et al 2001[5].

$$TCP = \frac{1}{1 + \left(\frac{TCD_{50}}{EUD}\right)^{4\gamma_{50}}}$$

Equation 1. Niemierko and Goiten TCP Model

Results

Results from the couch model validation (Table 1) demonstrated good agreement between predicted dose and measured dose when the couch and rails were included in the dose calculation. When they are ignored (representing common clinical practice), measurements were up to 6.2% different from calculations.

Plan Delivery	*% Difference w/couch and rails included*	*% Difference w/couch and rails <u>not</u> included*
IMRT Rails Out	0.6%	4.8%
IMRT Rails In	0.4%	1.7%
RapidArc Rails Out	0.7%	3.1%
RapidArc Rails In	0.7%	2.7%

Table 1. Average percentage differences between measured and calculated doses for QA plans that included the couch and rails, and for plans that did not include these structures .

Sample results for plan subtractions are shown in Figures 2 and 3. The areas of color indicate direction and magnitudes of dose loss when the attenuation from the couch and rails are not factored into the treatment plan. Note that for IMRT, the dose loss is along the posterior beams and for RapidArc along the rails.

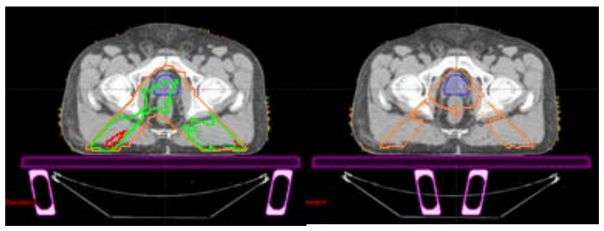

Figure 2. Representative IMRT dose differences between the no-couch, clinical scenario and other plan iterations showing spatially the areas of dose loss due to the couch and rails. Differences of 1, 2, and 3 Gy are shown in orange, green, and red, respectively. Prostate shown in blue colorwash.

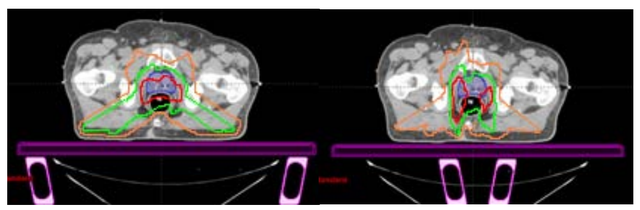

Figure 3. Representative RapidArc dose differences between the clinical scenario and other plan iterations showing spatially the areas of dose loss due to the couch and rails. Differences of 1, 2, and 3 Gy are shown in orange, green, and red, respectively. Prostate shown in blue colorwash.

The average dose and coverage loss to the prostate are shown in Tables 2 and 3 averaged over all patients.

	Rails Out	*Rails In*	*Imaging Couch Top Only*
Prostate Mean Dose Loss IMRT (%)	4.2%	2.0%	2.0%
Prostate Mean Dose Loss RapidArc (%)	3.2%	2.9%	2.0%

Table 2. Average percentage prescription dose losses to prostate target for IMRT and RapidArc plans.

Plan Type	*Clinical Scenario*	*Rails Out*	*Rails In*	*Imaging Couch Top Only*
Prostate Coverage IMRT (%)	100%	35%	84%	84%
Prostate Coverage RapidArc (%)	99%	18%	17%	40%

Table 3. Average volume coverage of target structures at the prescribed dose for IMRT and RapidArc plans.

The TCP results are shown in Table 4 averaged over all patients. TCPs are lower than predicted by the clinical scenario when the couch is included.

	Clinical Scenario	*Rails Out*	*Rails In*
IMRT TCP	90%	82%	87%
RapidArc TCP	88%	81%	81%

Table 4. Average TCP values for IMRT and RapidArc plans.

Conclusions

The attenuation of the posterior treatment fields for both IMRT and RapidArc plans by the treatment couch and support rails causes a clinically unacceptable loss of target dose and coverage during prostate cancer treatment.

The magnitude of target dose and coverage loss is clinically impactful to the extent that ignoring the couch and rails structures resulted in plan failure, on average, for all IMRT and RapidArc couch and rail positions. This is important as it represents a clinically unacceptable difference between what dose we think a plan will deliver to a patient and the reality of what is being delivered.

These losses manifested as a decrease the probability of controlling the tumor. The average loss of 6.3% in tumor control indicates that of the patients treated, 6.3% would be predicted to have tumor recurrence simply because the couch and rails were not taken into account during treatment planning.

To solve this discrepancy for IMRT, the rails should be moved to avoid the beam. However, the couch top itself caused clinically impactful losses and should be taken into account in treatment planning. For RapidArc, both the couch top and rails need to be accounted for in treatment planning.

References

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